ATTACHMENT 5B: ELECTRICAL SYSTEMS 1

ATTACHMENT 5B: ELECTRICAL SYSTEMS

5B.1 General

5B.1.1 Codes and Standards

Provide the electrical design in accordance with all applicable codes and the latest editions and applicable portions of the following:

- National Electrical Code (NEC)
- Phoenix Electrical Code
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories Inc. Standards (UL)
- The Institute of Electrical and Electronic Engineers (IEEE)
- American National Standard Institute, Inc. (ANSI)
- Illuminating Engineering Society (IES)
- Insulated Power Cable Engineers Association (IPCEA)
- National Electrical Safety Code

5B.1.2 General Electrical Materials

Perform all electrical work and provide all materials in accordance with the National Electrical Code. The above codes and standards shall be minimum requirements for electrical work and if there is a conflict between the requirements specified in this Service Agreement and the codes and standards, the more stringent will apply. Provide electrical materials and equipment that are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest standard design. When two or more units of the same class of material and equipment are required, these units shall be the products of the same manufacturer. All materials provided shall be new.

5B.1.3 Wiring Diagrams

The Company shall prepare point-to-point wiring diagrams for power and instrumentation wiring. All wires shall be labeled to conform to the wiring diagram labels. Conform wiring diagrams and labels to applicable City standards. In the absence of applicable City standards, conform to Good Engineering and Construction Practice.

5B.1.4 Identification for Systems and Equipment

General: Identify and label each raceway, piece of equipment and conductor. Develop a schedule for labels showing the legend of each. In the absence of specific data, develop legends from the nature of the service or system. Arrange the schedule to produce a legible comprehensive identification system in accordance with Section 5.6.5 of Appendix 5.

Raceway Identification: Identify exposed raceways at each end within 12 inches of point of termination. Provide factory manufactured identifying labels with colored paper machine printed with an identifying legend laminated between two sheets of vinylite plastic and formed to completely encircle the raceway. Match the size of the raceway on which they are being applied. Install labels in accordance with manufacturer's instructions. Legends used in the labels shall indicate the system voltage, the equipment served or type of service. The legend shall appear in a minimum of one inch high white letters on a black background for raceways 2-1/2-inch and smaller diameter and two inch high letters for raceways larger than 2-1/2-inch diameter.

Equipment Identification: Nameplates shall be attached to inside surfaces with adhesive and to the outside surface with round head, self-tapping metal screws. Nameplates shall be two-color laminated plastic not less than 1/16 inch thick, machine engraved to show white letters not less than 1/4 inch high on a black background. Legend shall identify the enclosure or piece of equipment.

Conductor Identification: Power conductors terminating in switchgear, motor control centers, motor starter enclosures, adjustable frequency drives, panelboards, control panels and special service outlets shall be identified at each end and in intervening junction and pull boxes. Where feeder conductors pass through a common box, tag the feeder to indicate the electrical characteristics, circuit number and panelboard designation. Labels shall be located near the conductor ends for terminals and on exposed portions of conductor within pull and junction boxes. Control wiring shall be identified at each end of each wire by a number conforming to the City standard for wiring identification. Wiring for auxiliary equipment shall be similarly identified. Where it is impractical to maintain the same wire numbers throughout, a terminal block shall be installed at the junction of the different numbered wires. On each side of the terminal block each associated wire number shall be typed or written in with permanent ink. Labels shall be plastic slip-on ferrule type with durable machine printed letters, numerals and other identifying characters.

5B.1.5 Basic Materials and Methods

5B.1.5.1 Raceways and Fittings

General - Minimum size shall be 3/4 inch. Fittings shall be of the same material and match the raceway.

Raceways - Rigid steel, heavy wall, hot-dip galvanized meeting requirements of UL-6 and ANSI C80.1. Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit meeting requirements of NEMA RN1. Electrical metallic tubing (EMT) shall meet requirements of UL-797 and ANSI C80.3. Rigid non-metallic shall be Schedule 40 or Schedule 80 PVC meeting requirements of UL-651 with solvent cement joints. Flexible metal conduit meeting requirements of UL-1. Liquid-tight flexible conduit shall be single strip steel, hot-dip galvanized with PVC jacket meeting requirements of UL-360. Electrical Plastic Conduit (EPC-40 and EPC-80) meeting requirements of NEMA TC2. Liquid-tight flexible conduit sizes 1-1/4 inch and smaller shall include a continuous copper bonding conductor wound spirally between convolutions on the inside of the conduit meeting requirements of UL-360. Aluminum ladder type cable tray meeting all of the requirements of NEMA Standard 11-15 of the load category required and a span category of 8 feet.

Fittings - Fittings shall be of the same material and finish as the raceways and shall meet requirements of UL-514 and ANSI C80.4. Threaded connectors shall be used for all rigid metal conduits. For enclosures, cabinets and boxes in dry areas use nylon insulated bushing and lock-nut. For enclosures, cabinets and boxes in wet areas use watertight hub fitting with gasket. Connectors for liquid-tight flexible conduit shall have factory installed liner of plastic in areas of contact with conductor insulation. Neoprene sealing rings shall be provided when conduit is installed in knockout. Provide stainless steel hardware for all cable tray connections.

Miscellaneous Specialty Fittings - For exterior walls, roofs and where required to be watertight, provide watertight sealing sleeves for raceway penetrations consisting of a steel sleeve with pressure ring and clamps or an assembly of molded rubber links with pressure plates and through bolts which may be tightened at any time. Seal between raceway and concrete shall withstand 25 feet of water head without leaking. For interior walls, floors and where not required to be watertight, provide schedule 40 galvanized steel pipe sleeves and plastic expandable sealant. Provide raceway expansion fittings where raceway crosses building or concrete expansion joints. Provide bonding jumper with each expansion fitting. Provide divider strips in cable tray for isolation of dissimilar wiring system.

5B.1.5.2 Raceway Supports

Support raceway at intervals and at locations as required by the NEC. Do not use perforated straps or plumbers tape for conduit supports. Independently support raceways from the structure. Supports and hangers shall be steel, hot dip galvanized after fabrication. Fasteners for concrete shall be expansion bolts or inserts, toggle bolts for hollow masonry or frame construction and preset inserts for pre-stressed concrete. For raceways supported on surface, provide straps with holes for one or two fasteners and shaped to fit raceway size. At structural steel members support raceway with hot dip galvanized beam clamps. Drilling or welding may be used. For suspended raceways, provide galvanized hanger rods not less than 3/8-inch diameter for raceways up to 2-inch diameter and 1/2 inch diameter rods for raceways larger than 2-inch diameter. Rods shall be threaded a minimum of 1-1/2-inches on each end to permit adjustment. For multiple suspended raceways, the horizontal channel shall not be less than 1-1/2 inches square by 12 gauge. Weld two or more together when greater strength is required to limit deflection to 1/2000 of span. Hanger for the horizontal channel shall be sized for the number and size of raceways supported. Exposed raceways on walls below grade, in damp, wet or corrosive locations shall be installed with standoff brackets providing a minimum of 1/4-inch air space between the raceway and the mounting surface. Where raceway may be affected by dissimilar movements of the supporting structures or medium, provide flexible or expansion devices. Use PVC coated or non-metallic channel throughout.

5B.1.5.3 Raceway Applications:

Electric Metallic Tubing (EMT) – Use indoors with compression type fittings in finished areas.

PVC coated rigid steel conduit – Use indoors and outdoors where routed exposed and in corrosive areas unless otherwise noted.

Rigid steel conduit – Use exposed in Electrical Rooms, concealed in building structures or concrete-encased within building structures.

Schedule 40 PVC conduit – Use underground concrete-encased, direct buried and embedded in structural concrete slabs.

Schedule 80 PVC conduit – Use underground direct buried where crossing roadways.

Flexible metal conduit – Use for making connections to recessed lighting fixtures.

Liquidtight flexible conduit – Use for connections to equipment subject to adjustment, movement or vibration.

Ladder type cable tray – May be used in lieu of PVC coated rigid steel where exposed indoors in unfinished areas except for areas defined as corrosive. All wiring to and from the cable tray shall be routed in conduit.

Install conduit with no more than the equivalent of three 90-degree bends between boxes and enclosures. Provide no more than 125 feet of continuous conduit before providing boxes for pulling of conductors.

5B.1.5.4 Wire and Cable - 600 Volts and Below

General: Conductors shall be copper, 98 percent conductivity, soft annealed copper meeting requirements of ASTM B33. All 600-volt cable shall be stranded with type THHN/THWN insulation except, solid No. 12 AWG and No. 10 AWG may be used for lighting fixture and convenience outlet wiring. For cable tray applications, provide type TC cable, multi-conductor stranded rated 600 volts with ground conductor, type THHN/THWN insulated conductors and a PVC overall jacket. Minimum conductor sizes shall be as follows:

- Power and lighting branch circuits No. 12 AWG.
- 120 volt control circuits, low energy control and signal circuits, No. 14 AWG.

Identification: Wire cable shall have following information surface printed at regular intervals throughout the entire length: manufacture or trade name, size of conductor, type of insulation and voltage classification.

Color Coding: Comply with the City's standard for color coding as defined in Section 5.6.5 of Appendix 5.

Wire Connections and Connecting Devices: Splice connectors for conductors No. 10 AWG and smaller gauge solid conductors shall be insulated pressure twist-on nut type. Splice connectors for No. 8 AWG and larger gauge conductors shall be compression type for making parallel or butt splices. Provide companion preformed plastic insulating covers or tape equivalent to conductor insulation. Provide solderless terminal lugs for stranded and multiple solid conductors at connection to terminals or use UL listed crimp tool compression style lugs. Control conductor connection terminations shall be either spade lug or pressure type.

5B.1.5.5 Medium Voltage Cables

General: Provide single conductor medium voltage power cable consisting of stranded copper conductors, conductor screen, insulation, insulation screen, metallic shield and outer jacket, suitable for use in wet and dry locations in conduit, underground concrete encased ducts, direct buried and aerial installation. Provide cables rated 105 degrees C for continuous operation, 140 degrees C for emergency overload operation and 250 degrees C for short circuit conditions, UL listed as Type MV-105 in accordance with UL 1072 and manufactured in accordance with AEIC CS6.

Conductors: Provide soft drawn, annealed and uncoated copper conductors with 98 percent minimum conductivity and Class B stranding.

Conductor Screen (Shield): Provide conductor screen of an extruded layer of semiconducting, thermosetting compound.

Insulation: Provide conductor insulation based on a thermosetting ethylene-propylene elastomer compound. The insulation shall be resistant to heat, moisture, impact, ozone and electrical discharge. Provide insulation meeting the following parameters.

- Nominal 4160-volt applications
  - Voltage rating 8kV
  - Insulation thickness 115 mils
  - Insulation level 100 percent
- Nominal 12.47kV applications
  - Voltage rating 15kV
  - Insulation thickness 220 mils
  - Insulation level 133 percent

Insulation Screen (Shield): Provide an insulation screen of an extruded semiconducting compound in accordance with Table D-1 of AEIC CS6.

Metallic Shield: Provide a 5 mil thick helically applied coated copper tape shield over the insulation screen with a 20 percent minimum overlap.

Outer Jacket: Provide a continuous outer jacket of polyvinyl chloride. The average thickness of the jacket shall be as specified in Part 4 of ICEA. The minimum thickness at any point shall not be less than 80% of that specified.

Splice Kits and Connections: Provide splice kits and terminations specifically designed for the application and recommended by the cable manufacturer. Make-up splices and connections with closed end compression connectors and terminal lugs.

5B.1.5.6 Plant Monitoring and Control System Cabling

5B.1.5.6.1 Fiber Optic Data Cable

Fiber optic cable shall meet the following summary specifications:

Fiber Type: Multimode.

Core Diameter: 62.5 microns.

Cladding Diameter: 125 microns.

Cable Outside Diameter: 13.3 mm (0.52 in).

Cable Weight: 191 kg/km (128 lbs/1000ft).

Maximum Attenuation: 3.5 dB/km @ 850 nm and 1.0 dB/km @ 1300 nm.

Bandwidth: 160/500 (MHZ X km)2

Buffer Type: Loose tube, gel filled.

Number of Fibers: 12.

Cable Central Strength Member: Dielectric.

Cable Fill: Water blocking gel.

Outer Jacket: MDPE.

Maximum Pulling Load: 600 lbf (2700 N).

Operating Temperature Range: -40 C to +70 C.

Parallel Plate Crush Resistance: 400 lbf.

Packaging: Spools/reels, protected from shipment.

Fibers within the cable shall be color-coded so that each fiber may be individually identified. The color sequence suggested is as follows: blue, orange, green, brown, slate, white, red, black, yellow and violet. Dashed versions of the same colors may be used to continue the sequence, depending on the cable structure and fiber count.

The outer jackets of the cable shall be continuous, free from holes, splits, blisters or inclusions. The same requirement holds for any inner jackets within a given cable structure as well as for fiber coatings.

Materials used for fiber optic cable shall present no environmental or toxicological hazards as defined by current industry standards and shall comply with OSHA and EPA standards or applicable federal or state laws or regulations.

The color of the polyethylene outer jacket material shall be black in accordance with ASTM D 1248, and contain a suitable antioxidant substance. The carbon black used shall be furnace-type conforming to designation N 110 in accordance with ASTM D 1765. The carbon black content in the jacket material when measured in accordance with ASTM D 1603 shall be 2.6 percent ± 0.25 percent by weight. The light absorption coefficient of the jacket material shall be at least 400 when measured at a wavelength of 375 nm in accordance with ASTM D 3349.

Outer polyethylene jacket materials shall meet tensile strength and elongation minimum requirements for unaged and aged samples as follows:

- Tensile Strength at Break: 2800 psi (Unaged), 2100 psi (Aged).
- Elongation at Rupture: 400 percent (Unaged), 375 percent (Aged).

The cable jacket shrinkage test measures the shrinkage or expansion of a cable jacket exposed to temperature aging for a specified period of time. Maximum shrinkage shall be less than 5 percent for each specimen tested. The test procedure is described in EIA-RS-455, FOTP-86.

5B.1.5.6.2 Category 5 Data Cable

Provide cable having third party verification to TIA/EIA 568-A Category 5 requirements. Four pair stranded No. 24 AWG solid copper wire, polyethylene or polypropylene insulation, stranded No. 24 AWG tinned copper drain wire, overlapped metalized tape overall shield providing 100 percent shield coverage, and outer jacket of gray PVC.

5B.1.5.7 Boxes

Boxes on conduit raceways shall be made of the same material as the conduit except on PVC conduit use PVC coated steel. Outlet, junction and pull boxes for use in dry areas shall be one piece galvanized sheet steel knock-out type a minimum size of four inches square or octagonal and 1-1/2 inches deep. Provide appropriate and compatible cover for each box. Boxes for use outdoors exposed and specifically in corrosive, damp and wet areas shall meet requirements of NEMA 4, be PVC coated cast steel or cast iron with threaded external hubs for conduit entrance a minimum size as stated for boxes in dry areas. Boxes shall have gasketed cover plates and be PVC coated with stainless steel hardware.

5B.1.5.8 Wiring Devices

Toggle Switches - Provide specification grade switches with a minimum rating of 20 amperes.

Receptacles – Provide specification grade convenience receptacles with a minimum rating of 20 amperes. Provide ground fault interrupter type receptacles for all installations outdoors, below grade, damp locations and otherwise required by code. Provide special purpose receptacles of the type, rating and number of poles required.

Device Plates - Device plates for outlets shall be one piece suited for the device installed. Plates on unfinished walls shall be zinc-coated sheet steel or cast metal with rounded edges. Plates on finished walls shall be satin finish stainless steel. Screws shall be countersunk heads with color and finish to match plate. Plates for GFCI type receptacles for the areas listed shall be weatherproof, gasketed, clear flame retardant, jumbo polycarbonate covers that allow the cover to be closed when the receptacle is in use.

5B.1.5.9 Terminal Cabinets

Cabinets shall be complete with a concealed hinged door(s), back panel to mount terminal blocks, and terminal blocks. Sheet steel cabinets shall be primed and finished coated inside and outside with the manufacturer's standard finish. Stainless steel cabinets shall not be painted. NEMA 4X cabinets shall be provided with quick release latches. Furnish sufficient terminals to accommodate all active and spare conductor terminations plus 30 percent extra terminations, unless otherwise noted. All terminals and back panels shall be mounted from the front of the cabinet. Mounting where a fastener extends through the back of the cabinet is acceptable only for NEMA 1 cabinets. Panels for dry areas shall meet requirements of NEMA 1 and be galvanized minimum 16 gauge steel, surface or flush

mounted. Panels for outdoors, damp, and corrosive areas shall meet requirements of NEMA 4X and be minimum 16 gauge stainless steel with stainless steel accessories and hardware. Non-metallic NEMA 4X enclosures are not acceptable. Terminal strips shall be standoff mounted and be the channel mounting type with marking strips.

5B.1.5.10 General Purpose Dry Type Transformers

Provide ventilated dry type transformers designed for continuous operation with a normal life expectancy as define in NEMA ST 20 and the performance obtained without exceeding 80 degrees C average temperature rise by resistance or 145 degrees C hot spot temperature rise in 40 degrees C maximum ambient and 30 degrees C average ambient. Do not exceed 185 degrees C maximum coil hot spot temperature. Insulate with 220 degree C temperature insulating material. Features are to include a minimum of two 2 ½ percent full capacity taps above and below nominal voltage in the primary winding. Provide with electrostatic shielding between the windings and with a K factor of not less than 13. Three phase transformers are to be connected 3-wire delta on the primary and 4-wire solidly grounded wye on the secondary. Single phase transformers are to be connected 2-wire on the primary and 3-wire mid point solidly grounded on the secondary. Furnish with sound levels not exceeding the average sound level in decibels as stated in NEMA ST 20 for the kVA ratings furnished. Mount transformers on one inch of sound absorbing material.

5B.1.5.11 Panelboards

Panelboards shall meet requirements of UL-67 and in addition, those used as service disconnects shall meet requirements of UL-869. Panelboards shall be factory assembled, dead front, safety type equipped with circuit breakers and designed so individual bolt-in-type breakers can be removed and replaced without disturbing adjacent units or without loosening or removing insulation supplied to obtain clearances as required by UL. Panelboards shall be sized to accommodate the number of single, double and three pole breakers as required. Provide for a minimum of six single pole spare spaces in each panelboard. Cabinets for the panelboards shall be equipped with a continuous piano hinged door trim covering. Inside the door, mount a removable directory behind a transparent protective covering to indicate and identify the different circuit breakers. Panelboard door shall be provided with a lock with two keys provided per lock. Door locks shall be keyed alike. The panelboard cabinets shall be shop primed and finish-painted inside and outside with manufacturer's standard paint system. Each panelboard shall be provided with main and neutral buses insulated from the cabinet and a ground bus bonded to the cabinet. Buses shall be copper with ampere rating as required. Support bus bars on bases independent of the circuit breakers. Buses shall be designed so

circuit breakers may be changed with simple tools without machining, drilling or tapping. Make complete provisions for mounting future circuit breakers throughout the entire length of the bus regardless of the number of units and spaces specified. Provide solderless main lugs for main, neutral and ground bus bars. Provide circuit breakers on 240 volt systems or less with an interrupting rating of 10,000 amperes rms symmetrical. Provide circuit breakers on 480 volt systems with an interrupting rating of 65,000 amperes rms symmetrical. Limit all lighting and receptacle circuits to 70 percent of the circuit breaker rating. Alternate the circuiting of the receptacles throughout so that adjacent receptacles of the same voltage are served from different circuit breakers.

5B.1.5.12 Enclosed Circuit Breakers

Circuit breakers for enclosed application shall meet requirements of UL489 with interrupting capacity as required and shall be UL listed as suitable for the type of conductor provided. Circuit breakers shall be molded case, quick-make, quick-break, thermal magnetic trip type, trip indicating and bolted in type. Provide visible trip rating on each breaker. Single pole breakers shall be full module size. Two and multiple pole circuits shall be of the common trip type having a single operating handle. Single pole circuit breakers with handle ties for multiple pole breakers are not accepted.

5B.1.5.13 Disconnect Switches

Disconnect safety switches shall be fusible or non-fusible with ampere rating, voltage rating, number of poles and enclosure type as required. All switches shall be of the heavy-duty type. Mechanisms shall have quick-make, quick-break operating handles with provisions for padlocking in the OFF position, interlock to prevent unauthorized opening of the cover when the switch is in the ON position and to prevent closing the switch mechanism with the cover open.

5B.1.5.14 Grounding

Grounding Electrodes: Provide ground rods of stainless steel minimum 3/4-inch diameter and not less than ten feet long. Provide a ground rod access box for each where installed outdoors with the top of the box installed flush with the finished surface. Provide access boxes having a H-20 traffic rating. Install ground rods with a poured ground enhancement material to reduce the impedance of the grid.

Ufer Grounds - Provide a minimum twenty foot length of 4/0 bare copper conductor encased in the footing of structures. Terminate the exposed end of the bare conductor on a bare copper ground bus

mounted on the wall adjacent to where the conductor exits the concrete. Terminate grounding electrode conductors to the ground bus using bolted lug connections.

Ground Conductors and Fittings:

- Ground Conductors: Provide stranded, bare, soft drawn, copper cable or bar not less than the equivalent in gauge of 12 AWG. Provide green insulated grounding conductors for installation in raceways.
- Grounding Fittings: Ground clamps shall be copper alloy multi-bolt type, saddle clamp or compression type assembled with bronze bolts, nuts and washers. Welded connections shall be the exothermic process.

5B.1.5.15 Motors

General: Provide all polyphase motors designed for high energy efficiency and high power factor operation. Provide inverter duty, IGBT compatible motors when powered from an adjustable frequency drive. Motors shall operate continuously over the entire load range of the driven equipment without loading the motor in excess of the nameplate rating and its specified temperature limit. Rate motors for continuous operation in 50 degree C ambient. Use motors with copper windings throughout.

Mechanical Protection:

- Indoor Locations
  - Dry, clean and well ventilated: Open drip-proof
  - Wet, damp or corrosive: Totally enclosed fan cooled
- Outdoor Locations
  - Dry and clean: Open drip-proof w/splash guard
  - Wet, damp or corrosive: Totally enclosed fan cooled
- Totally Enclosed Motors: Furnish with removable drain plugs

Design and Insulation: Provide NEMA Design B, unless otherwise required with NEMA Class F moisture resistant insulation and NEMA Class B, 80 degrees C temperature rise at rated nameplate load. When powered from an adjustable frequency drive, provide insulation to protect against adverse affects of a non-sinusoidal waveform.

Service Factor: Provided motors with a 1.15 service factor for sinusoidal voltage waveforms and 1.0 for non-sinusoidal voltage waveforms. Where motors with a 1.0 service factor are provided, provide motors rated at least 15 percent greater than the required break horsepower.

Shaft Loading: Provide steady state shaft loading not to exceed 100 percent of the full load rating under maximum load excluding the service factor.

5B.1.5.16 Indoor Lighting

Provide general illumination throughout all structures meeting the required illumination levels. Apply switching, occupancy sensors, energy saving ballasts and lamps, innovative controls, etc., for maximizing the efficient use of the overall lighting system while reducing energy consumption. Use specification grade fixtures throughout. Connect a portion of the general lighting and supplemental fixtures as required to the emergency power system for providing safe egress from all structures upon failure of the normal utility power. Provide sufficient emergency lighting levels in all areas for continuous operation of the process in that area.

Minimum Illumination Levels:

LOCATIONS	FOOTCANDLES
Tunnels, Stairs, Galleries, Corridors	10
Toilets, Locker Rooms, Chemical Rooms	20
Process Equipment Areas, Pump Rooms	40
Mechanical Rooms, Blower Rooms, Lobby	40
Electrical Rooms, Maintenance Shops, Lunch Room	50
Offices	70
Laboratory, Control Room	75

5B.1.5.17 Security and Surveillance Systems

Plant: Provide a security system that will monitor intrusion of all buildings and the status of all doorways throughout the Plant Site and access entries on the Finished Water Reservoirs. Transmit each monitoring point to a local area alarm panel that in turn is capable of repeating each alarm to the Main Control Room in the Operations Building via the Plant's Distributed Control System. The Distributed Control System equipment at the Main Control Room shall output a general intrusion alarm for remote monitoring via the Company's system with an option to connect to the City's water department SCADA system or designated central monitoring system. Provide bulletproof glass on all exterior windows of the Main Control Room in the Operations Building. Provide security cameras at the access entries on the Finished Water Reservoirs, all Plant Site entrance gates, and other vulnerable areas identified in the Company's vulnerability assessment performed in accordance with EPA requirements, in sufficient number to ensure the Plant Site is secure. The security system shall have motion sensors and be equipped for night vision. Provide video monitors in the Operations

Building for viewing the camera-covered areas. Equip each Plant Site entry gate, exterior doors to all structures and secured rooms with a card reader that enables Company and City personnel to enter that location. Each person shall be assigned a unique access card that shall be logged into a database for each use of the access card. Provide remote control of and voice communications with all Plant Site entrance gates from the Operations Building video monitoring area.

Raw Water Pumping Station: Provide a security system similar to that described for the Plant Site. Equip the main entry with a card reader that enables Company and City personnel to enter that location. Each person shall be assigned a unique access card that shall be logged into a database during each entry or exit to the Raw Water Pumping Station Site. Provide the local alarm panel with a general intrusion alarm for remote monitoring via the Raw Water Pumping Station's SCADA panel or designated central monitoring room. Provide security cameras at the Raw Water Pumping Station Site entrance gates and site perimeter in sufficient number to ensure that the Raw Water Pumping Station Site is secure. Provide security cameras at the Raw Water Pumping Station Site entrance gates and other vulnerable areas identified in the Company's vulnerability assessment performed in accordance with EPA requirements, in sufficient number to ensure the Raw Water Pumping Station Site is secure.

Provide the City with access cards to all access gates. Specific features of the surveillance and security equipment are provided in Attachment 5D.

5B.2 Electrical Service and Distribution

5B.2.1 Raw Water Pumping Station Electrical Service

The Company shall coordinate with the Arizona Public Service Company (APS) and provide an incoming electrical service to the Raw Water Pumping Station consisting of two 12.47kV, 3 phase, 4 wire, wye power lines from redundant APS sources to an outdoor substation yard located on the Raw Water Pumping Station Site. One power feeder shall be from the existing 12.47kV overhead power lines passing in close proximity to the Raw Water Pumping Station Site. The second feeder shall be a new underground feeder from the APS Humbug Substation routed in the City right of way for the Raw Water Transmission Line. The Company shall provide the complete associated conduit system. APS will install and terminate the conductors. The Company shall pay all costs associated with providing electrical service to, and at the Raw Water Pumping Station Site, including all costs associated with work performed by APS. The equipment in the yard shall consist of APS-owned switching cabinets and automatic transfer switch serving City-owned redundant substation

transformers with primary and secondary overcurrent protection devices, isolation switches, protective relaying and primary revenue metering designed in accordance with APS guidelines. The entire outdoor substation yard including all electrical apparatus, supporting structures, equipment pads and grounding shall be designed in accordance with APS guidelines. Locate the revenue metering out side of the substation yard in an accessible area for reading by APS personnel. The transformers shall be rated 12,470Y/7,200Von the primary with the secondary voltage to be determined by the Company. The secondaries shall connect to an indoor line-up of equipment with a main-tie-main circuit breaker arrangement. The main breakers shall be normally closed and the tie breaker normally open. The line-up of equipment shall be designed with the capacity to serve all of the electrical loads through the Phase II expansion of the Facilities (i.e. to a Plant Finished Water production capacity of 160 mgd). Provide individual feeder circuit breakers to serve each of the Raw Water pumps' starters through the Phase II expansion. Provide a minimum of one spare breaker with stationary compartment connected on one main bus and a minimum of one stationary compartment space provided on the other main bus. Balance the Raw Water Pumping Station electrical loads equally on each main bus. Design and provide all elements of the electrical distribution system for a 25% increase over the connected load requirements through the Phase II expansion. House all electrical distribution equipment in an air conditioned electrical equipment room. Provide elements of the electrical distribution system necessary to maintain a 90 percent minimum overall power factor.

Provide a Short Circuit and Coordination Study for the entire Raw Water Pumping Station electrical distribution system.

5B.2.2 Plant Electrical Service

The Company shall provide an incoming electrical service to the Plant consisting of dual 69kV, 3 phase overhead power lines from APS to an outdoor substation yard. The City will pay for APS to provide redundant high voltage overhead power lines to the substation on the Plant Site and terminate the conductors at the substation APS breaker. The Company shall provide all other services related to and shall pay for all other costs associated with providing electrical service at the Plant Site. The Company shall coordinate its activities with those of APS. The Company shall construct the electrical substation on the Plant Site. The equipment in the yard shall consist of APS-owned primary main and tie breakers with isolation switches arranged in a loop in loop out configuration. The load side of the APS primary breakers shall feed City-owned redundant substation transformers with primary circuit breakers, isolation switches, secondary overcurrent protection devices, lightning arresters, protective relaying and revenue metering. The entire outdoor

substation yard including all electrical apparatus, supporting structures, equipment pads and grounding shall be designed in accordance with APS guidelines. Locate the revenue metering out side of the substation yard in an accessible area for reading. The transformers shall be rated 69kV, 3 phase on the primary with the secondary voltage to be determined. The secondaries shall connect to an indoor line-up of equipment with a main-tie-main circuit breaker arrangement for distributing power on site. The main breakers shall be normally closed and the tie breaker normally open. The line-up of equipment shall be designed to serve all of the electrical loads through the Phase II expansion. Provide feeder circuit breakers on each bus to serve groups of radial fed redundant pad mount transformers. Locate redundant pad mount transformers in transformer yards adjacent to key process areas through out the Plant Site to serve the area electrical loads. Provide air conditioned electrical rooms within each key process area to house the electrical equipment associated with each. In the line-up of equipment, provide a minimum of one spare breaker with stationary compartment connected on one main bus and a minimum of one stationary compartment space provided on the other main bus. Provide pad mount transformers rated for the primary and secondary design voltage selected with a secondary line-up consisting of a main-tie-main circuit breaker arrangement sized for the load to be served. Balance the Plant electrical loads equally on each main bus. Design and provide all elements of the electrical distribution system for a 25% increase over the connected load requirements through the Phase II expansion. If the Company elects to use standby generators to provide the required emergency Finished Water pumping capabilities required by Section 5.4.6 of Appendix 5, the Company shall provide standby generators wired in parallel to automatic paralleling equipment to serve the Finished Water pumps, Finished Water Pumping Station supporting systems and the Operations Building upon sensing the failure of utility power. Arrange the paralleling equipment bus with a tie breaker and the number of generators equally divided on each bus. Provide feeder breakers on each bus to serve the identified loads. Provide elements of the electrical distribution system necessary to maintain a 90 percent minimum overall power factor.

Provide an Electrical Building to house the line-up of equipment served from the outdoor substation yard, standby generators, generator supporting systems and other miscellaneous electrical distribution equipment. Provide an air conditioned electrical equipment room for this equipment. Provide an adjacent walled-in outdoor yard area to house the standby generators.

Provide a Short Circuit and Coordination Study for the entire Plant electrical distribution system.

5B.2.3 Medium Voltage Switchgear

Provide 15kVand 5kV class metal clad indoor switchgear consisting of main, tie and distribution breakers, and incoming line metering and protection system. The switchgear and components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA SG-4 and SG-5, IEEE, and ANSI 37.20.2.

Ratings for 15kV class Switchgear: Maximum Voltage: 15kV RMS, BIL Rated: 95kV, Short Circuit Current @ Rated Maximum kV: 35kA RMS, Nominal 3 Phase MVA Class: 750MVA.

Ratings for 5kV class Switchgear: Maximum Voltage: 4.76kV RMS, BIL Rated: 60kV, Short Circuit Current @ Rated Maximum kV: 29kA RMS, Nominal 3 Phase MVA Class: 250MVA.

Stationary Structure: Provide completely dead front, totally enclosed, freestanding vertical sections housing circuit breakers and auxiliaries and bolted together to form a rigid metal clad switchgear assembly. Build each vertical section out of welded structural steel members with formed or fitted sections of smooth sheet steel. Isolate circuit breakers, buses, instrument transformers and cable terminations with separate compartments formed by sheet steel barriers. Provide a front hinged door panel for each compartment. The stationary structure shall include the insulated buses, the fixed portion of primary disconnect devices, insulated connections, instrument transformers, control devices and fuses.

Main and Ground Bus: Provide insulated copper bus of suitable design and cross-sectional area to satisfactorily carry the rated current without exceeding the temperature rise specified in the IEEE and NEMA standards and capable of withstanding the ANSI 60 hertz standard production test voltages. Provide a copper ground bus extending the entire length of the switchgear.

Circuit Breakers: Provide horizontal drawout type vacuum breakers capable of being withdrawn on rails. Equip the main and tie breakers with keyed mechanical interlocks which prevents closing the tie breaker when both main breakers are closed. Provide each breaker with a microprocessor based, three phase, overcurrent protection and microprocessor based metering and protection system.

Auxiliary Devices: Provide dry type current transformers suitable for indoor service in metal clad switchgear rated as required for the application. Provide potential transformers on a designed drawout carriage with primary and secondary disconnect devices, current limiting type primary fuses, grounding device and accessories conforming to ANSI, IEEE and NEMA standards. Equip each incoming service with lightning arresters and surge capacitors.

Microprocessor Based Metering and Protection System: Provide microprocessor based units with the following features:

- 6 digit LED indicating readout.
- UL recognized component meeting IEEE C37.90.
- Housed in a NEMA 12 suitable for door mounting.
- Derive control power from an integral control power transformer via a uninterruptable power supply.
- Auto ranging metering of the following values:
  - AC Amperes in each Phase, 1% Accuracy
  - AC Voltage, Phase-to-Phase, Phase-to-Neutral, 1% Accuracy
  - Watts, 2% Accuracy connect to EMS so power usage can be monitored and recorded
  - Vars, 2% Accuracy
  - Power Factor, 4% Accuracy
  - Frequency, 0.5% Accuracy
  - Watt Demand, 2% Accuracy with programmable 5,10,15, 30-minute intervals
  - Watt Hours, 2% Accuracy
- Protection system providing the following functions:
  - Voltage phase loss, less than 50% nominal line voltage
  - Current phase loss, less than 1/16 of the largest phase
  - Voltage phase unbalance, 5 to 40% in 5% increments
  - Phase voltage reversal
  - Overvoltage, 105 to 140% in 5% increments
  - Undervoltage, 95 to 60% in 5% increments
  - Time delay for overvoltage, undervoltage, and phase unbalance, zero to eight seconds in one second intervals
  - Separate Form C (NO/NC) trip and alarm outputs contacts rated 10 amperes at 115 VAC or 30 VDC resistive
  - Addressable communications card capable of transmitting all data over a two wire network. At the Plant, transmit data to the Plant SCADA system. Provide similar equipment at the Raw Water Pumping Station for future use by the City.

Protective Relays: Provide protective relays meeting the following requirements:

- Wired so that the tripping current of the circuit breaker trip coil will be interrupted by means other than relay contacts.
- Furnish relays with the characteristics including tap and time dial setting meeting the requirements of the Short Circuit and Coordination Study.
- Microprocessor Based Three-Phase Protective Relay
  - Install a single microprocessor-based multi-functional protective relay with true RMS sensing that provides phase time over-current, instantaneous over-current and ground fault protection, ANSI 50/51, 50/51G, or 50/51N.

- Design the relay to operate from the 5-ampere secondary output of current transformers. Design the relay to provide ANSI 50/51N protective functions for each of the three (3) phases, and ANSI 50/51N or 50/51G ground fault protection functions. Design the ground element to utilize residual, zero sequence, or ground source connection schemes, or be deactivated.
- Provide a relay with separate programmable setting for phase and ground current transformers with primary current ratings from 5 through 5,000 amperes.
- Provide a relay with phase and ground protection curves that are independently field selectable and programmable with or without load from the following type of curves:
  1) IEEE: Moderately inverse, very inverse, extremely inverse
  2) IEC: A, B, C, or D
  3) Thermal: Flat, lt, l^2t, l^4t
  4) Selectable short delay pick-up and short delay time settings
  5) Instantaneous phase over-current trip - field programmable pick-up points from 1.0 to 25 times current transformer primary rating or NONE.
  6) Provide a field selectable (ON or OFF) discriminator circuit that operates when phase instantaneous over-current has been programmed to NONE, to protect against currents exceeding 11 times current transformer primary rating, only when the breaker is closed.

- Design the relay with two field configurable type "a" contacts.
- Provide a built-in alphanumeric display capable of displaying the following information:
  1) Individual phase currents
  2) Ground current
  3) Cause of trip
  4) Magnitude and phase of current causing trip
  5) Peak current demand for each phase and ground since last reset
  6) Current transformer primary rating
  7) Programmed phase and ground set points.

- Furnish a relay having integral manual testing capability for both phase and ground
- Furnish an addressable communication card capable of transmitting all data over a two-wire network to the Plant SCADA System.
- Design the relay so that the Alarm and/or Trip contacts do not change state if power is lost or an Under-voltage occurs. Design the contacts to only cause a trip upon detection of an over-current or fault condition based upon programmed settings.
- Furnish a relay suitable for operating on control power with a nominal input voltage of 120 volts AC derived from an uninterruptable power supply.

- IEEE/ANSI 86-Lockout relay hand reset.
- If the Company elects to provide standby generators to provide the required emergency Finished Water pumping capabilities as required by Section 5.4.6 of Appendix 5, the Company shall provide relays relating to the paralleling of standby engine generators of the

drawout type with targets, test switches and devices incorporated into the relay unit and as follows:

- IEEE/ANSI 25-Synchronism-check relay with semi-flush case.
- IEEE/ANSI 27-Undervoltage relay with target and semi-flush case.
- IEEE/ANSI 27/59-Undervoltage and overvoltage relay with target and semi-flush case.
- IEEE/ANSI 32-Reverse power relay with target and semi-flush case.
- IEEE/ANSI 40-Loss of excitation relay with target and semi-flush case.
- IEEE/ANSI 81-Frequency relay with target and semi-flush case.

Control Devices: Provide control devices meeting the following requirements:

- Provide control switches of the standard rotary, multistage type suitable for the use specified.
- Design all circuit breaker control switches for use with red and green indicating lamps, and provide with indicating targets.
- Provide rectangular or round transformer base LED type indicating lamps designed for 120-volt ac except in the Finished Water Pumping Station switchgear and Standby Generator switchgear if the Company elects to provide generators to provide the required emergency Finished Water pumping capabilities as required by Section 5.4.6 of Appendix 5. Provide rectangular or round LED type indicating lamps with resistors designed for 48-volt dc.
- Furnish the following:
  - Other controls which may be required for moving the breaker to and from the operating position
  - Auxiliary relays, switches and mechanisms required for the particular manufacture of the breaker
  - Operation counter
  - Manually operated trip bar or lever
  - Provision for manual closing

5B.2.4 Substation Transformers

Provide substation transformers made up of factory built standardized units, oil filled, dead front, totally enclosed and freestanding with side wall or top mounted primary and secondary terminations including accessories, controls and metering with auxiliary compartments as required. Provide transformers capable of furnishing 112% kVA at 65 degrees C. The transformers shall be designed, manufactured and tested in accordance with the latest applicable standards, IEEE C57.12.00 and IEEE C57.12.90.

Ratings:

- Primary Voltage: 12.47kV, wye at the Raw Water Pumping Station and 69kV at the Plant
- Secondary Voltage: As required

- Temperature Rise @ Rated kVA in 40 degree C ambient: 55/65 degrees C
- BIL: 95kV for 12.47kV and 350kV for 69kV
- Impedance: +/- 5.75 %
- Phases: 3
- Hertz: 60
- Primary Taps: two 2 ½% full capacity above and below normal taps

Coils: Use coils wound with copper conductors.

Insulating Fluid: Inhibited mineral oil.

Accessories:

- Padlockable tap changer for de-energized operation
- One-inch upper filling plug and filter press connection
- One-inch drain valve with 3/8-inch sampler
- Dial type thermometer
- Pressure/vacuum gauge
- Magnetic liquid level gauge
- Ground pad
- Alarm contacts on all gauges
- Pressure relief diaphragm to operate @ 10 psi and relieve 10,000 scfm @ 15 psi

Primary Fused Disconnect Switch at Raw Water Pumping Station: Provide a simple radial medium voltage fused interrupter switch of the load break type with current limiting power fuses in a weatherproof outdoor enclosure designed, manufactured and tested in accordance with the latest applicable standards and IEEE C37.20.3.

- Switch Ratings:
  - Nominal Voltage: 15kV
  - BIL: 95kV
  - Continuous Current: 600 amperes
  - Interrupting Current: 600 amperes
  - Fault Closing: 61,000 amperes
  - Momentary Current: 80,000 amperes
- Accessories:
  - Insulated handle adjustable fuse puller
  - Set of special tools as required

Primary Power Circuit Breakers at Plant: Provide a three-pole, single throw outdoor SF-6 power circuit breaker in accordance with APS requirements and as follows. Ratings on symmetrical current basis, Reference: ANSI C37.06

- Maximum Voltage: 72.5kV
- BIL: 350kV
- Continuous Current: 1200 amperes
- Short Circuit Current: 40,000 amperes
- Interrupting Time: 3 Cycles

Secondary Circuit Breaker: Provide a secondary circuit breaker of the class required housed in a metal clad outdoor switchgear enclosure with walkin aisle and having ratings and accessories as specified under Section 5B.2.3.

5B.2.5 Pad Mounted Transformers

Provide dead front, oil filled pad mounted outdoor enclosed transformers with tap changer, high and low voltage cable and device compartments, load make and break primary line disconnect switch, fuses and secondary main circuit breaker. Provide transformers capable of furnishing 112% kVA at 65 degrees C. The transformers shall be designed, manufactured and tested in accordance with the latest applicable standards.

Ratings:

- Primary Voltage: As Required.
- Secondary Voltage: As Required.
- Temperature Rise @ Rated kVA in 40 degree C ambient: 55/65 degrees C
- BIL: 95kV for 15kV class and 75kV for 5kV class
- Impedance: +/- 5.75 %
- Phases: 3
- Hertz: 60
- Primary Taps: two 2 ½% full capacity above and below normal taps

Insulating Fluid: Inhibited mineral oil.

Compartments: Provide high and low voltage cable compartments with the high voltage section on the left. Arrange and mechanically interlock the compartment doors to allow access to the high voltage compartment only after the low voltage door is open.

- High Voltage Section:
  - Radial feed dead front construction with load break plug in bushing inserts
  - Load break oil-immersed rotary gang switch
  - Drywell canister with drawout current limiting fuses
- Low Voltage Section:
  - Close coupled bolt in low voltage power circuit breaker, 100% rated with solid state sensor logic circuitry, programmable trip unit with true rms sensing, manual operating handle, on/off pushbutton to close and open breaker and a minimum interrupting rating of 65,000 rms symmetrical amperes.

Accessories:

- Padlockable tap changer for de-energized operation
- One-inch filling plug and filter connection
- One-inch drain valve with 3/8-inch sampler
- Dial type thermometer
- Pressure/vacuum gauge
- Magnetic liquid level gauge
- Ground pad in high and low voltage compartments
- Pressure relief device that auto vents at 10 psi and recloses and seals when pressure falls to 6 psi.
- Two hook sticks
- Diagrammatic nameplate

5B.2.6 Standby Power Generation

If the Company elects to provide standby generators to provide the required emergency Finished Water pumping capabilities as defined in Section 5.4.6 of Appendix 5, the Company shall provide standby power for the Finished Water Pumping Station and Operations Building. The standby power supply shall be sufficient to operate the Operations Building and the Finished Water Pumping Station at any flow rate demanded by the City between 20 and 60 mgd until all of the reserve emergency Finished Water has been delivered to the Water System. Provide sufficient space, electrical equipment capacity and necessary rough-ins to expand and upgrade the system to meet the requirements for emergency Finished Water pumping capability through the Phase II expansion.

5B.2.6.1 Finished Water Pumping Station

If the Company elects to provide standby generators to provide the required emergency Finished Water pumping capabilities as defined in Section 5.4.6 of Appendix 5, the Company shall provide engine driven standby generators operating at the required voltage, designed to meet applicable local,

state and federal emissions and sound attenuation standards. Provide generators to serve the specified loads with sufficient spare capacity to make up the difference if one generator is taken out of service for maintenance. Provide the engine driven generators in outdoor sound attenuated enclosures with critical grade silencers sufficient to meet the Performance Guarantees for noise. House the generators in an outdoor yard with walls and fencing to screen the generators from view. After the Phase II expansion, the standby power supply shall be sufficient to operate the expanded Operations Building and Finished Water Pumping Station at any flow rate demanded by the City between 20 and 120 mgd until all of the expanded reserve emergency Finished Water (80 million gallons) has been delivered to the Water System.

Provide a similar isolated space to house the electrical paralleling equipment and associated electrical distribution equipment. Provide within the same space, sufficient room to house the line-up of equipment associated with the secondaries of the outdoor substation transformers. Provide additional dedicated space to house the standby generators supporting systems. Upon loss of normal utility power, the generators shall start and parallel automatically to serve the designated loads. When normal utility power returns, the generators shall unload with the loads transferred back automatically to the normal source. Generators shall operate unloaded for an adjustable time interval for cooling down and shutoff automatically. Provide controls for exercising the generators to Plant loads and controls which allow for manual or automatic starting and paralleling of the units. Provide the engine generators with either battery or compressed air starting systems. If compressed air starting systems are used, provide redundant air compressors with a common air receiver tank and a complete air piping system to serve all of the engine generators that will use compressed air starting systems through the Phase II expansion. If diesel-fueled generators are used, provide above-ground fuel storage tanks with fuel oil coolers sized for the initial number of generators required with space for additional storage tanks and fuel oil coolers required for the Phase II expansion. Size the storage tanks such that there will be sufficient standby fuel at all times to meet the emergency Finished Water delivery requirements defined in Section 5.4.6 of Appendix 5. This will require extra storage capacity for exercising generators between scheduled fuel deliveries. Size the generation system to have 25 percent additional capacity beyond that required to start the largest motor with all other loads operating at nameplate rating. Provide day tanks to serve the individual units. In addition to the electrical equipment already described, provide each generator with a main disconnect device.

5B.2.6.2 Additional Standby Power Requirements for Plant

If engine driven standby generators are provided across the Plant Site to serve emergency lighting, security systems and critical process data circuits, size the generators to accommodate the initial circuit requirements with provisions to expand the system to accommodate the Phase II expansion. Connect the described loads to branch circuits in emergency panelboards. Provide normal and emergency power feeds to the emergency panelboards via automatic transfer switches. Provide engine driven generators indoors in dedicated building spaces or outdoors in self-contained enclosures with all required appurtenances. Provide engine generators with critical grade silencers. Provide units with base mounted fuel tanks if diesel fueled. Provide tanks of suitable size to provide 24 hours of continuous operation at full load. Where units are outdoors, provide sound attenuated enclosures and silencers sufficient to meet the Performance Guarantees for noise.

5B.2.6.3 Standby Generator

The generator unit is to function as an emergency/standby power source for use in the event of failure of the incoming normal power service and during normal exercising operations. The unit consists of an engine-driven generator mounted on a structural steel base, complete with instrument panel, generator circuit breaker/main disconnect device and generator control panel, starting system, governor, engine jacket water cooling system, exhaust silencer, voltage regulator, starting battery where applicable, outdoor enclosure where applicable, and all appurtenances necessary for a complete functioning generation system.

5B.2.6.3.1 Engine

Provide a water cooled engine Vee type or in line type, cylinders as required, turbo-charged if necessary, aftercooled, four stroke cycle compression ignition operating on diesel oil or natural gas. Provide an engine equipped with fuel, lube oil and air intake filters with replaceable elements, lube oil cooler, gear driven coolant pump, fuel priming and transfer pump where required, engine jacket water heater, pressure relief bypass valve and engine mounted d-c generator with voltage regulator and ammeter to furnish a battery charging current where applicable. Provide an engine having exhaust valve seats replaceable with inserts. Provide the engine directly connected to the generator and the set mounted on a common structural steel base through suitable spring type vibration isolators.

- Engine fuel/water separator: On diesel-fueled engines, provide a fuel/water separator mounted ahead of the fuel pump on the engine generator set to remove fuel tank

condensation and to prevent water from entering the engine fuel system. Provide a separator capable of being heated to prevent freezing and resultant damage.

- Engine Lubrication: Provide an engine-driven, gear type lubricating oil pump with removable suction screen to force oil under pressure to all main, connecting rod, piston, wrist pin and cam shaft bearings, timing gears and governor operating mechanism. Furnish a full flow lubrication oil filter of the replaceable cartridge type and a lubrication oil cooler for the engine. Provide a bypass valve in the filter assembly to allow engine lubrication in case the filter is clogged. Fill the engine crank case with an approved lubricating oil in accordance with the manufacturer's instruction.
- Engine Speed Governor: Provide an isochronous governor to control the engine speed and maintain a steady state frequency regulation within 0.25 percent (0.15 hertz) from no load to full load.
- Engine Jacket Water Heater: Provide an engine mounted thermal circulation type water heater(s) operating at 208-volt, single phase and incorporating a thermostatic switch to maintain the engine jacket water at 90 degrees F.
- Engine Exhaust Pipe and Silencer: Provide the exhaust pipe and silencer suitable for a critical grade installation, fabricated with welded Schedule 40 steel pipe and "IR" sweep elbows with the horizontal piping pitching downward away from the engine. Provide No. 316 stainless steel flexible connectors to connect engine exhaust silencer and exhaust stack. Provide a valved silencer drain with a drip pocket having a minimum capacity of two gallons. Provide a minimum 2-inch thick "Metal-On" insulation with aluminum cover over exhaust pipe and silencer. Provide all supports for securing the exhaust pipe and silencer to the weather protective enclosure where applicable and to the generator building structure (if applicable).
- Engine Jacket Cooling System: Provide a permanent corrosion inhibited 50 percent by volume cooling solution of water and ethylene glycol rated for -40 degrees F operating temperature for the cooling system.
- Engine mounted radiator: Equip the engine with an engine-mounted radiator, blower fan and close fitting shroud, sized to provide cooling for engine jacket water, lubricating oil and after cooler water cooling requirements at a maximum day temperature of 120 degrees F averaged over 24 hours. Provide a rigid guard to enclose both the top and sides of all moving parts between the engine and radiator. Furnish the radiator with a duct flange.

5B.2.6.3.2 Generator

Provide a generator rated for continuous standby service at its kW rating, 0.8 power factor, voltage as required, three phase, three/four wire, Delta/wye connected, 60 Hertz, 1800 rpm, with a temperature rise not exceeding 125 degrees C in an ambient temperature of 40 degrees C.

Provide a generator 4 pole, salient pole, synchronous, revolving field, static regulated, brushless excited with Class F insulation in a totally enclosed fan-coded enclosure connected to the engine through a flexible coupling and a ring bolted to the flywheel housing.

Provide a generator of the single bearing design with the rotor dynamically balanced within 0.0005 inch. peak to peak amplitude displacements at both ends of the shaft, capable of sustaining 25 percent overspeed.

Provide the generator stator and rotor windings of the layered form wound design with amortisseur windings furnished in pole faces having welded type connections.

Provide a generator excitation system consisting of a rotating rectifier assembly, 3-phase ac exciter and a solid state voltage regulator. The exciter will consist of a stationary field structure and a revolving armature. Provide surge suppressors to protect rotating rectifiers.

Provide the generator capable of withstanding 10 percent overload current for two hours and 50 percent overload current for one minute without injurious heating at the rated power factor and exciter field set for normal rated load excitation.

Provide a generator having a minimum combined efficiency of 95 percent with the exciter and voltage regulator at rated full load current.

Provide a generator, exciter and regulator with radio and TV noise suppression.

5B.2.6.3.3 Automatic Voltage Regulator

Provide an automatic, high speed, solid state, static voltage regulator mounted in the generator control panel; to monitor the generator output voltage in all three phases and apply corrections to generator excitation for variation in the voltage due to changes in generator load current, engine speed and load power factor.

Provide the voltage regulator to maintain generator output voltage within plus or minus one percent of the rated voltage from no load to full load, and momentary voltage drop at the maximum 20 percent of rated voltage when full load is applied.

5B.2.6.3.4 Main Disconnecting Device

Provide one enclosed load-break fusible switch or circuit breaker depending on the voltage application to act as a service disconnect and overcurrent protection device with a withstand rating suitable for the application.

5B.2.7 Low Voltage Switchgear

Provide 600V class metal enclosed indoor switchgear consisting of two mains, tie and distribution breakers, and incoming line metering and protection system. The switchgear and components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA SG-3 and SG-5, IEEE C37.13, C37.20.1, C37.51, and C37.90 and ANSI 37.20.

Ratings:

- 600VAC service
- Assembly rated to withstand an available fault current of 65,000 amperes symmetrical
- Bus system with a minimum 4-cycle short circuit withstand rating of 100,000 amperes symmetrical

Stationary Structure: The switchgear shall consist of the required number of vertical sections bolted together to form a rigid assembly approximately 90 inches high. Each vertical section shall be a self contained housing having one or more individual breaker or instrument compartments. Isolate circuit breakers, buses, instrument transformers and cable terminations with separate compartments formed by sheet steel barriers. Provide a front hinged door panel for each compartment. The stationary structure shall include the insulated buses, the fixed portion of primary disconnect devices, insulated connections, instrument transformers, control devices and fuses.

Main and Ground Bus: Provide insulated copper bus of suitable design and cross-sectional area to satisfactorily carry the rated current without exceeding the temperature rise specified in the IEEE and NEMA standards and capable of withstanding the ANSI 60 hertz standard production test voltages. Provide a copper ground bus extending the entire length of the switchgear.

Circuit Breakers: Provide horizontal drawout type, manually operated, 100 percent rated power air circuit breakers capable of being withdrawn on rails. Equip the main and tie breakers with keyed mechanical interlocks which prevent the closing the tie breaker when both main breakers are closed. Provide each breaker with a microprocessor based trip unit with the following protection features.

- Trip Indicators
- Long time setting and time delay
- Short time setting, time delay and I2t response
- Instantaneous setting (distribution circuit breakers only)
- Ground fault setting, time delay and I2t response
- Short time and ground fault zone interlocking
- Capable of transmitting all data over a two wire network to the Plant SCADA system.

Auxiliary Devices: Provide dry type current transformers suitable for indoor service in metal enclosed switchgear rated as required for the application. Provide potential transformers on a designed drawout carriage with primary and secondary disconnect devices, current limiting type primary fuses, grounding device and accessories conforming to ANSI, IEEE and NEMA standards. Equip each incoming service with lightning arresters and surge capacitors.

Microprocessor Based Metering and Protection System: Provide microprocessor based units with the following features:

- 6-digit LED indicating readout.
- UL recognized component meeting IEEE C37.90.
- Housed in a NEMA 12 suitable for door mounting.
- Derive control power from an integral control power transformer via an uninterruptable power supply.
- Auto ranging metering of the following values:
  - AC Amperes in each Phase, 1% Accuracy
  - AC Voltage, Phase-to-Phase, Phase-to-Neutral, 1% Accuracy
  - Watts, 2% Accuracy connect to EMS so power usage can be monitored and recorded
  - Vars, 2% Accuracy
  - Power Factor, 4% Accuracy
  - Frequency, 0.5% Accuracy
  - Watt Demand, 2% Accuracy with programmable 5,10,15, 30-minute intervals
  - Watt Hours, 2% Accuracy
- Protection system providing the following functions:
  - Voltage phase loss, less than 50% nominal line voltage
  - Current phase loss, less than 1/16 of the largest phase
  - Voltage phase unbalance, 5 to 40% in 5% increments
  - Phase voltage reversal
  - Overvoltage, 105 to 140% in 5% increments
  - Undervoltage, 95 to 60% in 5% increments
  - Time delay for overvoltage, undervoltage, and phase unbalance, zero to eight seconds in one second intervals.
  - Separate Form C (NO/NC) trip and alarm outputs contacts rated 10 amperes at 115 VAC or 30 VDC resistive.
  - Addressable communications card capable of transmitting all data over a two wire network. At the Plant, transmit data to the Plant SCADA system. Provide similar equipment at the Raw Water Pumping Station for future use by the City.

5B.2.8 Medium Voltage Solid State Motor Starters

If utilized, provide 5kV class solid state reduced voltage starters in totally enclosed, dead front, freestanding enclosures designed for operation on a 4.16kV, 3-phase, 60 hertz, grounded power system. Provide equipment designed, manufactured and tested in accordance with the latest applicable standards, ANSI C37.90, ANSI C37.46, NEMA ICS 2 and UL 347. Provide motor controllers with current limiting fuses for control and protection of 4kV, 3-phase, 60 hertz induction motors. Design all controls to operate at 120-volts, 60 hertz.

Solid State Reduced Voltage Starters: Provide solid state reduced voltage starters consisting of an isolation switch, current limiting fuses, main contactor, bypass contactor, solid state power assembly and microprocessor control logic providing closed loop current ramp for smooth and stepless motor acceleration and deceleration.

Ratings:

- Input Power: 4.16kV, 3-phase, +/- 10 percent 60 Hz
- OL Rating: 500% of starter FLA for 30 seconds and 125% continuous
- Short Circuit Rating: 50,000 amperes rms symmetrical
- Efficiency: Greater than 99% with or without the bypass contactor engaged

Components and Features:

- Door interlocks to prevent opening of doors when power is applied
- Main and bypass contactors of the vacuum type, fixed mounted and rated for the required load. Bypass contactor to bypass the SCRs after starting and while the starter is operating at full voltage.
- Manually operated load break isolation switch with the following ratings:
  - Maximum Voltage: 5.5kV
  - BIL Rating: 60kV
  - Load Switching Current: 400 amperes rms
  - Continuous Current, Interrupting Capacity and Fault Current Closing ratings for the required load.
- Door mounted digital operated keypad with LCD display to allow setting of all programmable parameters and control functions as follows:
  - Power ON
  - Start / Stop pushbuttons
  - “Local-Remote” control selection
  - Line current, voltage and frequency
  - Elapsed time meter

    - Diagnostic package with fault indication
- Addressable communications card capable of transmitting the following data over a two wire network to the Plant SCADA system:
    - Status (ON, OFF, TRIPPED)
    - Input and output current in each phase
    - Input and output kW
    - Cause of trip
- Dry contacts to indicate the following functions:
    - Running
    - Up to Speed
    - SCR Failure
    - Motor Overload Trip
    - General Fault alarm
- Instrument Transformers as required
- Power Transducer (Watts)
- Microprocessor Based Motor Protection Relay with protection functions, control functions and monitoring functions, trip and alarm output contacts and an addressable communications card capable of transmitting data over a two wire network to the Plant SCADA system.
- Control relays of 600 volt class of machine tool quality with 10 ampere rated contacts at 120 volts, 60 Hz.
- Control Devices:
    - Heavy duty oiltight, 30.5mm pushbuttons and selector switches
    - 1 inch diameter, LED type low voltage push to test indicating lights with transformer base for operation at 120-volt, 60-Hz.

5B.2.9 480V Motor Control Centers

Provide motor control centers consisting of main, tie and distribution breakers, NEMA rated motor starters and incoming line metering system. Provide 25 percent additional space in fully bussed structures for all motor control centers. The motor control center and components shall be designed, manufactured and tested in accordance with the latest applicable standards, IEEE C37.90, NEMA ICS 2, NEMA 250 and UL 845. Design all control devices for operation at 120-volts, 60 Hertz. Provide all control equipment and devices meeting the 600-volt insulation class.

Ratings:

- Designed for 480-volt, 3-phase, 3-wire, 60 Hertz operation
- Main Bus Rating: 600 amperes minimum
- Vertical Bus Rating: Sized to carry the served load
- Ground Bus Rating: 300 amperes minimum
- Bus Bracing Withstand Rating: 65,000 rms amperes

- Circuit Breaker Interrupting Rating: 65,000 rms symmetrical amperes
- Motor Circuit Protectors Interrupting Rating: 65,000 rms symmetrical amperes

Basic Structures: Provide totally enclosed, dead front, rigid, NEMA 12, gasketed, self-supporting and freestanding structures. Provide busses of silver plated copper bars across each structure of suitable design and cross-sectional area to satisfactorily carry the rated current without exceeding the temperature rise according to UL. Cover the rear of each structure with removable steel panels. Design with cable compartments the full length of the motor control center and vertical wiring space in each structure between the breaker/starter cells and the side sheet steel.

Individual Units: Fabricate combination motor controller and circuit breaker units to be not less than 12-inches high. Design and wire each unit so that all devices are serviceable from the front. Provide each unit with a hinged door. Equip the doors for motor control compartments with a motor circuit protector operating mechanism, thermal overload relay reset mechanism, controls and indicating lights and other required devices as shown. Equip the doors for branch feeder equipment with a circuit breaker operating mechanism. Arrange the circuit breaker operating mechanism or handle to be padlocked in the OFF position.

Wiring: Provide NEMA Class II, Type B wiring for the motor control center internal wiring. Use #14 AWG, Type SIS stranded switchboard wire for control interconnections.

Combination Magnetic Starters: Provide NEMA rated starters minimum size 1 rated 480-volts, 3-phase, 60-Hz with individual control power transformers. Provide starter contacts of the replaceable type. Use Class 20 thermal overload elements and overload relays of the bimetallic type with adjustment knob. Provide each starter in combination with a motor circuit protector with magnetic only adjustable trip. Equip starters and overload relays with auxiliary contacts.

Contactors: Provide NEMA sized, 30 ampere minimum rated contactors similar to the motor starters except without overload protection.

Circuit Breakers: Provide molded case type circuit breakers with a minimum voltage rating of 600-volts ac, thermal magnetic trips for all frame sizes 600 amperes and smaller and solid state trip units for all frame sizes above 600 amperes. Provide main and tie breakers with trip ratings of 1000 amperes and higher with adjustable ground fault pickup and delay setting. Provide main and tie breakers with key interlocks which prevents closing the tie breaker when both main breakers are closed.

Instrument Transformers: Provide transformers in an accuracy class to meet the requirements of ANSI Standards, and for the secondary burdens connected to the transformers. Provide dry wound type current transformers with fully coordinated insulation for 600-volt insulation class. Use window type current transformers for ground sensing where shown. Provide potential transformers rated at 480 to 120 volts.

Microprocessor-Based Metering and Protection System: Furnish a microprocessor-based metering and protection system consisting of the following features:

- 6-digit LED indicating readout.
- UL recognized component meeting IEEE C37.90.
- Housed in a NEMA 12 or 3R enclosure suitable for door mounting.
- Derive control power from an integral control power transformer via an uninterruptable power supply.
- Auto ranging metering of the following values:
  - AC amperes in each phase, 1 percent accuracy
  - AC voltage, phase-to-phase, phase-to-neutral, 1 percent accuracy
  - Watts, 2 percent accuracy
  - Vars, 2 percent accuracy
  - Power factor, 4 percent accuracy
  - Frequency, 0.5 percent accuracy
  - Watt demand, 2 percent accuracy with programmable 5-, 10-, 15-, 30-minute intervals
  - Watt-hours, 2 percent accuracy
- Protection system of the following functions:
  - Voltage phase loss, less than 50 percent nominal line voltage
  - Current phase loss, less than 1/16 of the largest phase
  - Voltage phase unbalance, 5 to 40 percent in 5 percent increments
  - Phase voltage reversal
  - Overvoltage, 105 to 140 percent in 5 percent increments
  - Undervoltage, 95 to 60 percent in 5 percent increments
  - Time delay for overvoltage, undervoltage, and phase unbalance, 0 to 8 seconds in 1-second intervals
- Separate Form C (NO/NC) trip and alarm outputs contacts rated 10 amperes at 115-volt ac or 30-volt dc resistive.
- Addressable communications card capable of transmitting all data to a central computer system via a two-wire network or through an RS-232C port.

Control Components: Provide control components as follows:

- Elapsed Time Meters: Provide non-reset type elapsed time meters to register up to 9999.9 hours suitable for panel mounting and rated for 120-volt, 60-Hz operation.

- Control and Latching Relays: Provide relays of 600-volt machine tool quality with convertible contacts rated a minimum of 10 amperes, 120-volt, 60-Hz.
- Timing Relays: Provide 4-pole, double throw, with timing ranges and ON DELAY or OFF DELAY operation as required and contacts rated a minimum of 10 amperes, 120-volt, 60-Hz.
- Reset and Repeat Cycle Timers: Provide electromechanical or solid-state type reset and repeat cycle timers with timing ranges and functions required and contacts rated a minimum of 10 amperes, 120-volt, 60-Hz. Solid state output contacts are not acceptable.
- Alternators: Provide alternators suitable for 120-volt, 60-Hz operation and similar rated contacts with a minimum 5 ampere rating. Provide alternators suitable for "lead-lag" and concurrent "standby stage" operation.
- Phase Failure and Undervoltage Relays: Provide a 3-phase monitor to detect phase failure, phase reversal, phase unbalance and undervoltage suitable for operation at 480-volts. Provide with an adjustable drop out voltage range of 380 to 500-volts and an adjustable time delay from 0.2 to 20 seconds. Provide with normally open and closed alarm contacts rated 10 amperes at 120-volts with automatic reset.
- Ground Fault Protection Relay: Provide a manual reset ground sensing relay suitable for use with a window type current transformer. Provide with an adjustable time delay and pickup settings and single pole, double throw alarm contacts rated 10 amperes at 120-volts.
- Control Power Transformers: Provide individual control power transformer for each starter to derive the 120-volts circuit for control. Provide transformers with sufficient capacity to meet the power demands for all of the related control components. Provide primary and secondary fusing with the unfused leg of the secondary grounded to the enclosure.
- Pushbuttons, Selector Switches and Indicating Lights: Provide the following:
  - Heavy duty oiltight, 30.5mm pushbuttons and selector switches
  - 1 inch diameter, LED type low voltage push to test indicating lights with transformer base for operation at 120-volt, 60-Hz.
- Feeder Cable Terminals: Provide closed-end, compression type solderless connectors and terminals suitable for copper conductors.

5B.2.10 Remote Control Stations

Provide heavy-duty, oiltight remote control stations consisting of pushbuttons, indicating lights and selector switches installed in NEMA 250 rated enclosures as follows:

AREA	ENCLOSURE
All Process Areas Indoors and Out	NEMA 4X – Stainless Steel
Air Conditioned Spaces	NEMA 12

Lockout Attachments:

- Pushbutton Type: Provide a pad-lockable attachment which holds the button depressed.

- Selector Switches: Provide a padlockable attachment which covers the selector switch operator and allows the switch to be locked in any position. Key operated switches are not acceptable.

Mount remote control stations 4 feet, 6 inches above the finished surface to the centerline.

5B.2.11 Manual Motor Starters

Provide thermal type manual toggle switches with neon pilot light for all 120-volt, single-phase motors rated less than ½ horsepower. Provide enclosures as listed under Remote Control Stations. Provide with Hand/Off/Auto selector switches where required.

Mount 4 feet, 6 inches above the finished surface to the centerline.

5B.2.12 Adjustable Frequency Drives

If utilized, provide adjustable frequency drives to vary the speed of NEMA standard, 3-phase, 460-volt induction motors and driven equipment by varying the frequency and voltage applied to the motors. Prepare a harmonic distortion study of the Plant electrical system to determine voltage and current harmonics at various adjustable speed drive speed and load settings. Design harmonic filtering system to maintain electrical disturbances to the drive supply below the requirements established by IEEE 519-1992 “IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems”. The adjustable frequency drive and components shall be designed, manufactured and tested in accordance with the latest applicable standards, IEEE 519, NEMA ICS 1, 2, 3 and 3.1. The point of common coupling (PCC) shall be defined as the motor control center, switchboard or switchgear directly upstream of the adjustable frequency drive.

5B.2.12.1 Performance Requirements

Provide adjustable frequency drives meeting the following requirements:

Total Harmonic Distortion THD (Voltage): Maximum of 5 percent for general distribution systems as measured at the point of common coupling.

Total Current Harmonic Distortion: Not to exceed the values in Table 10.3, Current Distortion Limits for General Distribution Systems (120V through 69000V) of IEEE-519 at the point of common coupling.

The point of common coupling is defined as the line side of the overcurrent device directly upstream of the adjustable frequency drive.

Minimum Efficiency: 95 percent

Operating Voltage Variation: +10 percent or –20 percent

Operating Frequency Variation: +/- 2-hertz

Maximum Operating Sound and Power Level: 96-decibels, A-weighted in accordance with IEEE 85

Operating Ambient Conditions:

- Ambient Temperature: 40 degrees C
- Humidity: 0 to 95 percent

5B.2.12.2 Design

Input Disconnect: Furnish an input circuit breaker with an interrupting rating of 65,000 rms symmetrical amperes.

Input Reactor: Furnish input reactor or isolation transformer, if required, as determined by system harmonic distortion analysis.

Converter Section: Design input section to convert 480-volts, 60-hertz, 3-phase input to a fixed dc with a bridged rectifier.

Filter Sections: Furnish dc link reactor and filter capacitors.

Inverter Section: Design adjustable frequency drive inverter section to convert the fixed dc voltage to an adjustable frequency output utilizing a pulse width modulation inverter. Maintain a constant volts per hertz ratio on the output with voltage boost for startup as required. Provide drive inverter section of the eighteen pulse design for all motors 75 horsepower and larger.

Control Devices: Include door mounted control and monitoring devices for each drive as follows:

- Start push button
- Stop push button
- Speed control potentiometer

- Frequency meter with hertz and 0-100 percent scales
- Output ammeter
- Elapsed time meter
- Diagnostics package with fault indication and reset push button

Control Features: Design a control system for each drive to allow the following functions:

- Remote, isolated 4-20 ma speed control input
- Isolated 4-20 ma speed output
- Alarm outputs
- ON/OFF status output
- Additional features and controls as specified with the driven equipment

Internal Control Adjustments:

- Acceleration time, 4 to 60 seconds
- Deceleration time, 4 to 60 seconds
- Minimum speed limit
- Maximum speed limit
- Inverter current limit
- Supply undervoltage trip

Protection Features: Provide with the following protection features:

- Input line current limiting fuses rated 200,000 rms symmetrical amperes short circuit current.
- Electronic overcurrent protection for instantaneous overload
- AC input line undervoltage protection, adjustable from 60-100 percent nominal voltage with time delay adjustment and low speed override.
- Overfrequency protection
- Phase loss protection
- DC overvoltage protection
- Logic supply voltage low level protection
- Line-to-line and line-to-ground output short circuit protection
- Line-to-line and line-to-ground surge arresters sized for 480-volt 3-phase grounded wye system
- Overload capability of 110% of the motor FLA based on the NEC ratings for 60 seconds
- Control circuit fuses
- Overtemperature protection
- Diagnostics module to indicate protection trip conditions

5B.2.12.3 Components

General: Furnish circuit breakers, fuses, transformers, push buttons, switches, indicating lights, relays and timers as specified under 480-Volt Motor Control Centers.

Power Solid State Components: Furnish power solid state switching components with a one minute current rating greater than 110 percent of rated current for variable torque drives or 150 percent of rated current for constant torque drives.

Control Power Transformer: Furnish a constant voltage control power transformer to maintain control power with supply voltage variations from 70-110 percent nominal.

Printed Circuit Boards: Apply a clear conformal coating of acrylic to all printed circuit boards.

Programmable Controller: Provide programmable controllers as specified under Instrumentation.

5B.2.12.4 Enclosures

Provide NEMA 1A enclosures for indoor applications and NEMA 4 for outdoor applications. Provide NEMA 4 enclosures with integral package air conditioning unit and thermostat for maintaining the internal temperature suitable for the specified operating ambient conditions.

5B.2.12.5 Wiring

Provide internal wiring with stranded switchboard wire having 600-volt rated, flame-resistant, type SIS insulation. Use No. 14 AWG wire for control interconnections. Provide power connections as required for the service.

Provide wire markers at each end of all wires.

Where wiring connections are made to equipment mounted on hinged doors, provide connections with extra flexible wires suitably cabled together and cleated.

Provide wiring of all control connections to all external connections through individual positive latch pull-apart type control terminal blocks rated 600-volts. Locate terminal blocks for front access.

Provide sufficient terminals for all devices external to the adjustable frequency drive.

5B.2.12.6 Installation Criteria

Provide adjustable frequency drives installed in motor control centers, individual enclosures or grouped in enclosures.

Unless the length of the output conductors exceeds the recommendations of the drive manufacturer, all drives are to be installed indoors in air conditioned electrical rooms. Where output conductor length necessitates an outdoor installation, locate the drive enclosure in close proximity to the motor being controlled.

5B.3 Site Electrical Utilities

5B.3.1 Site Electrical Distribution

5B.3.1.1 General

Provide a network of manholes and concrete encased underground duct banks for routing redundant primary medium voltage feeders, substation and pad mount transformers secondary feeders, miscellaneous low voltage feeders below 600-volts, instrumentation and communications wiring. Provide separate manholes to isolate the redundant primary medium voltage feeders and a designated low voltage manhole for all other wiring. Limit the distance between manholes so as not to exceed the recommended pulling tensions of the conductors being installed. Provide sufficient spare conduits routed and stubbed out for the Phase II expansion of the Facilities. If the initial building structures have space reserved for installation of future electrical equipment, provide conduits stubbed out to the locations of the future electrical equipment. For any electrical equipment that is intended to be replaced with larger equipment (e.g. pumps or motors) during future expansions of the Facilities, provide conduits sized for the future, larger equipment. Provide twenty-five percent spare conduits in each duct bank above those needed for the Phase II expansion for each group of conduits terminating in the same manhole or outdoor transformer. Slope all duct banks to manholes. Provide a continuous direct buried electrical warning tape a minimum of 12-inches above all duct banks. Provide reinforced concrete pads for all substation transformers, pad mount transformers and associated primary and secondary electrical apparatus. Provide direct buried conduits for all site lighting wiring and miscellaneous short runs of low voltage wiring beyond the structures.

5B.3.1.2 Concrete Encased Duct Banks

Provide duct banks with a minimum conduit size of 4-inches for low voltage and a minimum of 5-inches for medium voltage. Provide rigid plastic conduit spacers at approximately 4-foot intervals and steel reinforcing to maintain the spacing and configuration of conduits in all duct banks. Dye the concrete "RED" for all duct banks. Provide 12-foot radius horizontal bends and vertical deflections. Provide 3-foot minimum vertical bends turning up to equipment. Clean the inside of all conduits with a flexible mandrel followed by a brush with stiffer bristles. Provide a polypropylene pulling line in each conduit.

5B.3.1.3 Electrical Manholes

Provide precast concrete manholes designed to withstand the earth and hydrostatic pressures and a vehicular load of 20,800 lbs (H20 AASHTO truck rear wheel load of 16,000 lbs plus 30 percent impact). Provide manholes measuring approximately 6-feet, 6-inches square by 7-feet, 6-inches high inside with a 3-foot diameter opening on top. Provide each manhole with a cast iron manhole frame and solid cover suitable for H-20 truck loads with the word ELECTRIC cast in the cover and a frame with a 36-inch clear opening. Use concrete rings to level and raise the frame and cover to protrude 1-inch above unpaved ground or flush with finished surfaces. Within each manhole, provide pull-in irons, cable racks with supports and insulators, a wall mounted continuous bare copper ground bus located 12-inches above the floor, a driven ground rod in the manhole connected to the ground bus and the floor sloped to a dry sump in one corner. Place a 6-inch high compacted crushed stone base on the bottom of the hole under the entire floor slab.

5B.3.1.4 Direct Buried Conduits

Provide 1-inch minimum direct buried conduits installed a minimum of 36-inches below grade. Place a 6-inch layer of sand on trench bottoms for bedding all direct buried conduits and a continuous electrical warning tape 18-inches above the conduit. Where direct buried conduits pass under roadways use Schedule 80 PVC conduit.

5B.3.1.5 Outdoor Electrical Equipment Pads

Provide reinforced concrete pads for supporting substation transformers, pad mount transformers and associated primary and secondary switches and circuit breakers. Extend pads in front of switches and breakers to provide sufficient work space for operating and maintaining the equipment. Provide openings in pads for all conduit penetrations. Install grounding conductors through openings as well.

5B.3.2 Site Lighting

5B.3.2.1 General

All lighting shall be designated in accordance with City and State regulations governing light pollution. Provide an average level of illumination of 2 footcandles across the Raw Water Pumping Station Site and Plant Site on all roadways, parking areas, basins, reservoirs and the immediate area around buildings. Provide an average illumination level of 5 footcandles at all major outdoor process equipment areas with motorized equipment. Use lighting fixtures with high pressure sodium lamps of the highest color rendition index rating available. Provide circuitry and controls which switch all outdoor lighting circuits "on" at dusk and "off" at dawn. Furnish with a control feature that reduces the level of illumination by one-half at 9:00 PM with means to manual override this feature by areas. Arrange the controls to operate the overall lighting for specific areas. Centrally locate the master lighting controls with override switches in the Operations Building. Provide contactor controls throughout the Raw Water Pumping Station Site and Plant Site to perform the actual switching. In areas where security surveillance cameras are installed, increase the level of illumination to satisfy the requirements of the cameras and maintain the level of illumination required for the cameras for the entire illumination period. Furnish lighting fixtures with sharp cutoff photometrics or shielding meeting the criteria of the City of Phoenix Outdoor Lighting Ordinance. Use pole mounted lighting fixtures for illuminating roadways, parking areas, basins and top of reservoirs. Use wall mounted area lighting fixtures for illuminating the perimeter of buildings and structures with the emphasis on lighting the means of egress. Use a combination of the two fixture types to illuminate major outdoor process equipment areas as the physical configuration of the areas dictate. Install all pole-mounted fixtures at grade level on reinforced concrete bases with a driven ground rod installed for grounding each pole and fixture. Where pole mounted fixtures are subject to possible vehicular damage, install concrete bases extending 3-feet, 6-inches above the finished surface. Grout the top of all concrete bases flush with the bottom of the anchor bolt covers.

5B.3.2.2 Pole Mounted Lighting Fixture

Furnish roadway luminaires with the IES Type Distribution required for the application mounted on square tapered aluminum poles supported from a short mounting arm. Provide luminaires with a formed aluminum housing, anodized aluminum reflector and tempered glass lens. Provide square tapered aluminum poles with mounting arm, ground lug, flush handhole and anchor bolts with cover. Provide luminaires and poles designed to withstand a force of 100 mph wind with a gust factor of

1.3. Finish luminaires with a powder coat paint and the poles with an anodized applied color to compliment the architectural color scheme.

5B.3.2.3 Wall Mounted Outdoor Lighting Fixtures

Provide luminaires with die cast aluminum housings, stainless steel hardware, seated and gasketed optic compartment, impact resistant prismatic glass diffuser and finished with a powder coat paint matching that selected for the roadway luminaires and poles.

5B.3.2.4 Lighting Fixtures Illuminating Open Tanks and Channels

Utilize fixtures with metal halide lamps.

5B.4 Uninterruptable Power Systems

5B.4.1 Uninterruptable Power Supplies

Provide uninterruptable power supplies to serve the following systems and essential devices. Size for the specific loads as required. Furnish at the voltage required for the load being served.

- Electronic Metering and Protective Devices
- Security and Surveillance System
- Computers and Network Servers
- Water Services Department SCADA Equipment
- Process Instruments as directed by the City

Furnish the UPS designed with a rectifier charger, solid inverter, and sealed maintenance free lead/acid batteries with a battery protection time of not less than 15 minutes. Locate in close proximity to the equipment being served.

5B.5 Data Communications Systems

The Company shall arrange for a T1 line or fiber optic line to be provided to the Plant Site. From the location where the T1 line or fiber line enters the Plant Site, the Company shall provide two concrete-encased 4” conduits (one spare) from the property line of the Plant Site to the Operations Building. Provide 4”dedicated conduits with spares in the low voltage underground duct banks for connecting all of the structures on the Plant Site to the Operations Building. Provide T1 or fiber optic data cable for connecting the area control rooms to the central control room in the Operations

Building. Utilize Category 5 data cable to connect local system peripherals to area control rooms. Provide handholes as required for pulling in T1 or fiber optic cables underground.

In its master planning of the Sites, the Company shall include space for and show two future 4" diameter, concrete-encased conduits from the Operations Building to the Raw Water Pumping Station.

[This page left blank intentionally.]